SCANNING EXPOSURE APPARATUS AND METHOD

This application claims a benefit of priority based on Japanese Patent Application No. 2002-191329,

5 filed on June 28, 2002, which is hereby incorporated by reference herein in its entirety as if fully set forth herein.

BACKGROUND OF THE INVENTION

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The present invention relates to scanning exposure apparatuses and device fabrication methods using the same, and more particularly to an exposure apparatus suited to expose a large mask.

15 Recent displays, such as those of personal computers ("PCs") and televisions have frequently used liquid crystal display ("LCD") substrates. The LCD substrate forms a desired shape of patterned transparent thin-film electrodes on a glass plate using

20 the photolithography, and the photolithography uses a projection exposure apparatus for exposing an original pattern formed on a mask onto a photoresist layer on the glass plate via a projection optical system.

The projection optical apparatus includes those

25 types of so-called step-and-repeat and mirror projection manners.

The projection exposure apparatus has been requested to expand its exposure area with recent demands for a larger LCD substrate. FIG. 13 is a schematic view of principal part in a conventional scanning exposure apparatus of a common mirror-projection type. In FIG. 13, 1 denotes a mask, 2 a mask stage for scanning the mask 1, 4 a projection optical system, 5 a plate such as a glass plate, and 6 a plate stage for scanning the plate 5. UV reactive photoresist is applied onto a surface of the plate 5. 13 is arc-shaped illumination light from an illumination system 7.

As illustrated, the illumination system 7 generates the arc-shaped illumination light 13 using an arc-shaped aperture or a slit aperture arranged just before the mask 1 or at a position that is optically conjugate with the mask 1. Alternatively, use of an optical element such as a cylindrical lens would also provide similar arc-shaped illumination light.

11 denotes an XYZ coordinate system. The illuminated scanning exposure apparatus aligns a longitudinal direction of the arc-shaped illumination light 13 with the X-axis direction, a transverse direction or a scan direction of the mask stage 2 and the plate stage 6 with the Y-axis direction, and a direction perpendicular to the XY plane with a Z-axis direction.

A brief description will now be given of an operational principle. Only part 10 of a pattern on the mask 1 is projected and transferred which is subject to the arc-shaped illumination light. The entire circuit pattern on the mask 1 is projected and transferred onto the plate 5 by scanning the mask 1 at a specified speed in a direction of an arrow 9 as well as scanning the plate stage 6 in a direction of an arrow 8 at a speed of the former speed multiplied by an imaging magnification of the projection optical system 4.

A stage control system synchronizes the mask 1 and the plate 5, and controls their scans. After the entire circuit pattern is transferred, the plate stage 6 moves or steps by a specified amount in the directions X and Y to repeat a pattern transfer of many different locations on the plate 5 in the same way as described above, and expose an area larger than the drawn area on the mask.

A scan exposure with a large mask effectively enables an exposure apparatus for a broad exposure area to expose a large plate, such as a large-sized liquid crystal panel, with high throughput, and requires a pattern on the mask to focus on the plate across the entire broad exposure area.

A negative plate, such as a mask, would deform due to its own weight when supported horizontally.

According to the strength of materials, the mask's gravity deformation is proportionate to the fourth power of the length of one side of the mask, and remarkably increases as the mask becomes larger. For example, the following equation provides the maximum deformation y_{max} of a level mask with both edges freely supported:

$$y_{max} = (5wL^4) \ / \ 384EI \qquad\qquad (1)$$

where w is weight per unit length, L is a length of a supported interval, E is a Young's modulus, and I is a geometrical moment of inertia.

The maximum deformation of a level mask with both edges fixed is given by the following equation:

$$y_{max} = (wL^4) \ / \ 384EI \qquad\qquad (2)$$

For example, a quartz mask with L = 500 mm and a thickness of 10 mm has a maximum deformation y_{max} = 30 μm with both edges supported, or y_{max} = 6 μm with both edges fixed.

On the other hand, the mirror-projection type projection optical system has a depth of focus ("DOF") of approximately ±30 μm.

Therefore, the mask's gravity deformation cannot be negligible relative to the DOF of the mask pattern projected image, and would deteriorate transfer performance such as resolution.

Even when a mask support means 14 supports four surrounding sides of the mask on the same flat surface

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as in FIG. 5, a mask plane complicatedly deforms, as

shown in FIG. 6, providing different sectional shapes.

BRIEF SUMMARY OF THE INVENTION

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Accordingly, it is an exemplary object of the

present invention to provide a scanning exposure

apparatus, as well as a device fabrication method using

the same, which facilitates projection exposure onto a

10   large screen with high resolution illuminating a mask

that deforms due to its own weight, using arc-shaped

illumination light to expose a pattern on the mask onto

a plate through the projection optical system using a

scanning exposure method, and a mask support method for

15   arranging in place an arc-shaped illuminated mask

pattern image surface and a plate surface imaged by the

projection optical system.

A scanning exposure apparatus of one aspect of the

present invention includes an illumination optical

20   system for illuminating a pattern on a mask using arc-

shaped illumination light, a projection optical system

for projecting the pattern on the mask illuminated by

the illumination optical system onto a plate, a mask

stage for scanning the mask, a plate stage for scanning

25   the plate, the scanning exposure apparatus scanning the

mask stage and plate stage synchronously relative to

the projection optical system, a mask support mechanism

for supporting a peripheral of the mask, and a mask stage tilt mechanism for arranging the pattern in an area illuminated by the arc-shaped illumination light in an object-surface-side focal plane of the projection

5 optical system, wherein the mask deforms due to its own weight from the peripheral supported.

A scanning exposure apparatus of another aspect of the present invention includes an illumination optical system for illuminating a pattern on a mask using arc-

10 shaped illumination light, a projection optical system for projecting the pattern on the mask illuminated by the illumination optical system onto a plate, a mask stage for scanning the mask, a plate stage for scanning the plate, the scanning exposure apparatus scanning the

15 mask stage and plate stage synchronously relative to the projection optical system, a mask support mechanism for supporting a peripheral of the mask, and a plate stage tilt mechanism for arranging a surface of the plate in an object-surface-side focal plane of the

20 projection optical system which plane images the pattern in an area illuminated by the arc-shaped illumination light, wherein the mask deforms due to its own weight from the peripheral supported.

A scanning exposure apparatus of still another

25 aspect of the present invention includes an illumination optical system for illuminating a pattern on a mask using arc-shaped illumination light, a

projection optical system for projecting the pattern on the mask illuminated by the illumination optical system onto a plate, a mask stage for scanning the mask, a plate stage for scanning the plate, the scanning exposure apparatus scanning the mask stage and plate stage synchronously relative to the projection optical system, a mask support mechanism for supporting a peripheral of the mask, and a mechanism for tilting the mask stage and the plate stage for arranging a surface of the plate in an object-surface-side focal plane of the projection optical system which plane images the pattern in an area illuminated by the arc-shaped illumination light, wherein the mask deforms due to its own weight from the peripheral supported.

The mask support mechanism may support the mask at least at two sides parallel to and/or perpendicular to a scan direction. The mask support mechanism may support the mask only at two sides parallel to a scan direction. The mask stage tilt mechanism may tilt the mask relative to the scan direction by tilting a stage stool mounted with the mask. The scanning exposure apparatus may further include a projection magnification correction mechanism for correcting a projection magnification in a direction orthogonal to a scan direction. The scanning exposure apparatus may further include a stage control mechanism for synchronizing the mask stage and plate stage at a speed

ratio corresponding to a projection magnification of the projection optical system, and for scanning relative to the projection optical system, wherein the stage control mechanism adjusts the speed ratio

5 according to tilts of the mask and plate.

A scanning exposure method of another aspect of the present invention for illuminating a pattern on a mask using arc-shaped illumination light, and for projecting the pattern on the mask illuminated by the

10 illumination optical system onto a plate, the scanning exposure apparatus scanning the mask and plate synchronously relative to a projection optical system includes the steps of exposing a focus-measurement pattern mask, measuring a focus position of a specific

15 area from light intensity or resolution performance of a focus measurement pattern image on the plate, interpolating a measurement result linearly and identifying an image plane position, calculating a tilt angle for tilting the mask and/or plate to arrange a

20 surface of the plate on a focal plane at an image-surface position, correcting a tilt of a mask stage and/or plate stage based on calculated data, and exposing an actual mask.

The scanning exposure method may further include,

25 in measuring a focus state of the specific area from the focus measurement pattern, the steps of scanning only the focus-measurement pattern mask in a scan

direction, and identifying the image-surface position based on an output from a light quantity detector arranged in a specific exposure area.

The scanning exposure method may further include, in measuring the focus state of the specific area from the focus measurement pattern, the steps of exposing the focus-measurement pattern mask and a plate that applies a photosensitive material, in a scan direction, verifying a focus state from a sensitized image on the plate, and identifying the image-plane position based on verified data.

A device fabrication method of another aspect of the present invention includes the steps of exposing a device pattern onto a plate using the above scanning exposure method, and developing the plate that has been exposed.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is a schematic view of principal part of a first embodiment according to the present invention.

FIG. 2 is a schematic view of principal part of a second embodiment of the present invention

FIG. 3 is a schematic view of principal part of a third embodiment of the present invention.

FIG. 4 is schematic view of principal part of a fourth embodiment of the present invention.

FIG. 5 is a schematic view of a mask support method that absorbs four sides.

FIG. 6 is a view for explaining gravity deformation in a mask support method that absorbs four 5   sides.

FIG. 7 is a schematic view of a mask support method that absorbs two sides in a scan direction.

FIG. 8 is a view for explaining a gravity deformation in a mask support method that absorbs two 10   sides.

FIG. 9 is a view for explaining first to fourth embodiments and a stage correction amount.

FIG. 10 is a flowchart for acquiring a tilt correction amount.

15   FIG. 11 is a flowchart for explaining a device fabrication method according to the present invention.

FIG. 12 is a flowchart for explaining a device fabrication according to the present invention.

FIG. 13 is a schematic view of principal part in a 20   conventional scanning exposure apparatus.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

FIG. 1 is a schematic view of principal part of a 25   first embodiment according to the present invention, wherein 1 denotes a mask. A mask support method uses a mask support mechanism 15 shown in FIG. 7 to adsorb and

support the mask along its two sides in a scan

direction, and allows it to deform due to its own

weight, as shown in FIG. 8 in a direction or direction

Y orthogonal to the scan direction or direction X.

5 This method provides the mask with a constant sectional

shape. A mask stage stool 3 that supports a mask stage

2 inclines in a direction to correct an offset of an

imaging position of the arc-shaped illuminated pattern

10 on the mask or a direction to correct an optical

10 distance between the arc-shaped illuminated area of the

mask and the plate. The pattern on the mask is exposed

onto the plate 5 in this state. 4 is a projection

optical system, and 6 is a plate stage for supporting

the plate 5 made of a glass plate. UV reactive

15 photoresist is applied onto the surface of the plate 5.

Alternatively, the present invention may incline

the plate 5 rather than the mask 1 (as in a second

embodiment) or both of them simultaneously (as in a

third embodiment), as described later.

20 13 is arc-shaped illumination light from an

illumination system 7. As illustrated, the

illumination system 7 provides the arc-shaped

illumination light 13 using an arc slit-shaped aperture

or a slit aperture that is arranged immediately before

25 the mask 1 or at a position optically conjugate with

the mask 1. Alternatively, use of an optical element

such as a cylindrical lens would provide similar arc-

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shaped illumination light, and form an arc-shaped
illumination area pattern 10 on the mask pattern
surface.

As illustrated, 11 denotes an XYZ coordinate
system. The illuminated scanning exposure apparatus
aligns a longitudinal direction of the arc-shaped
illumination light 13 with the X-axis direction, a
transverse direction or a scan direction for the mask
stage 2 and plate stage 6 with a Y-axis direction, and
a direction perpendicular to the XY plane with a Z-axis
direction.

The instant embodiment projects and transfers only
part 10 of the pattern on the mask 1 which is subject
to the arc-shaped illumination light. The entire
circuit pattern on the mask 1 is projected and
transferred onto the plate 5 by scanning the mask 1 at
a specified speed in a direction of an arrow 9 as well
as scanning the plate stage 6 in a direction of an
arrow 8 at a speed of the former speed multiplied by an
imaging magnification of the projection optical system
4.

A stage control system synchronizes the mask stage
2 and the plate stage 6, and controls their scans.
After the entire circuit pattern is transferred, the
plate stage 6 moves or steps by a specified amount in
the directions X and Y to repeat a pattern transfer of

many different locations on the plate 5 in the same way as described above.

In supporting the mask 1, the mask support means 15 cannot mechanically intercept a light path of the above projection optical system. As the mask 1 and plate 5 are scanned relative to the projection optical system, the mask 1 can be supported at only its peripheral. Thus, the mask 1 deforms in a gravity direction due to its own weight. When this gravity deformation of the mask 1 is viewed from the projection optical system, center part of the mask 1 approaches to the plate 5 in the optical-axis direction of the projection optical system, and the peripheral separates from the plate in the optical-axis direction. As a result, a pattern or image shape on an image surface position through the projection optical system defocuses the center part and focuses the peripheral of the arc-shaped illuminated pattern.

The present embodiment cancels out a deformation of the mask by making constant a distance between the illuminated area 10 on the mask 1 and the illuminated area 13 on the plate 5 as follows:

The mask support means 15 in FIG. 7 initially supports the mask 1 so that the mask 1 is deformable due to its own weight in a specific direction, whereby the mask 1 is stable dynamically. The mask 1 or mask stage stool 3 then inclines to make constant a distance

between the illuminated area 10 on the mask 1 and the plate 5, whereby the part of the pattern irradiated by the arc-shaped illumination light corresponds approximately to the object surface of the projection optical system. Since the pattern image surface that is imaged via the optical system corresponds approximately to the surface of the plate 5, the arc-shaped pattern image focuses on the surface of the plate 5 for optimal exposure.

The gravity deformation of the mask magnifies a projected image in a direction orthogonal to the scan direction. Tilt of the mask or plate from the scan direction to the optical-axis direction magnifies a pattern image in the scan direction.

A magnification correction optical system 4a disclosed in Japanese Patent Publication No. 8-306618 filed by the instant applicant is applicable to correct an imaging magnification in a direction orthogonal to the scan direction. The stage control system changes a speed ratio between the mask 1 and the plate 5 to correct a projection or scan magnification in the scan direction.

A fixed support of edges of the mask does not make the mask pattern surface to be a perfectly cylindrical surface, and would cause distortion in a projected image. Nevertheless, this may be corrected by an optical correction means (not shown).

Thus, the present embodiment properly focuses the entire arc slit area, which has been difficult, and provides a pattern image corresponding to the performance of the projection optical system.

5   FIG. 2 is a schematic view of principal part of the second embodiment according to the present invention. This embodiment differs from the first embodiment of FIG. 1 in inclining the plate 5 instead of the mask 1 in exposing a pattern on the mask 1 onto

10   the plate 5. The other structure is almost the same.

Similarly, the mask 1 deforms due to its own weight when supported at its peripheral. The mask in this embodiment deforms and the pattern image surface on the plate 5 forms the central part of the arc-shaped

15   pattern image on a cylindrical side surface that bends towards the mask 1. Taking into this fact into consideration, the second embodiment inclines the plate 5 correspondingly and scans it for exposure.

A means for tilting the plate 5 may use, for

20   example, a tilt mechanism for a plate stage.

Thus, the embodiment properly focuses the entire arc slit area, which has been difficult, and provides a pattern image with high resolution.

FIG. 3 is a schematic view of principal part of

25   the third embodiment according to the present invention. This embodiment differs from the first embodiment of FIG. 1 in inclining both the mask 1 and the plate 5

relative to the scan direction to expose a pattern on the mask 1 onto the plate. The other structure is almost the same.

Similarly, the mask 1 deforms due to its own weight when supported at its peripheral. The mask in this embodiment deforms and the pattern image surface on the plate 5 forms the central part of the arc-shaped pattern image on a cylindrical side surface that bends towards the mask 1. Handling this phenomenon in an exposure system, the third embodiment inclines the mask 1 and plate 5 correspondingly and scans them for exposure.

This embodiment uses the mask support means 15 shown in FIG. 7 to support the mask 1, and then inclines both the mask 1 and plate 5 at the same time relative to the scan direction while maintaining constant a distance between the arc-shaped illuminated area 10 of the mask 1 and the plate 5.

In other words, instead of inclining only the mask 1 as in the first embodiment or only the plate 5 as in the second embodiment, this embodiment inclines both the mask 1 and the plate 5 at the same time.

The instant embodiment inclines both the mask 1 and the plate 5 at the same time with a smaller tilt amount to correct defocus than inclining either one separately.

Three embodiments have been discussed which simply incline the mask 1 and/or plate 5, and scan them in their longitudinal directions. The above embodiments are comparatively simple and effective ones.

5   Next follows a description of the invention that successfully handles with the problematic mask 1 with deformation shown in FIGs. 4 and 5 based on these embodiments.

The above three embodiments are also effective to 10 this case by supporting the mask 1 and/or the plate 5 so that they may be scanned in their longitudinal directions, adjusting their tilts at proper time, and preferably adjusting their tilt angles according to their scan positions.

15   For example, the deformation on the mask 1 caused by its own weight as shown in FIGs. 4 and 5 is correctable when the tilt angle linearly changes according to the scan position of the mask 1.

A description will be given with reference to FIG. 20 9 that is a view for explaining a relationship between a scan position and a tilt angle of the stages that support the mask 1 and/or the plate 5 in the above three embodiments.

The above three embodiments may scan at an almost 25 constant tilt angle "A" in FIG. 9. In this case, the tilt angle of the stage may be mechanically adjusted or controlled. On the other hand, it is fairly

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complicated for the deforming mask 1 shown in FIGs. 4
and 5. Originally, the present invention is remarkably
effective in an apparatus having a two-dimensional
exposure area. It is an exemplary object of the

5   present invention to align with the plate 5, positions
of the foremost and backmost scan patterns in the
optical-axis direction.

     It is important for the deforming mask 1 shown in
FIGs. 4 and 5 that the two-dimensional exposure area

10   accords with a top surface of the plate 5 statistically.
As shown by "B" in FIG. 9, this embodiment linearly
changes a relationship between the stage position and
the stage tilt angle. Part shown by a broken line in
FIG. 9 indicates an axially symmetrical two-dimensional

15   exposure area in the scan direction, while "B" in FIG.
9 is an asymmetrical one in the scan direction.
Scanning for the asymmetrical area requires balancing
the focusing state between the foremost and backmost
patterns in a scan pattern.

20   Since the mask 1 has a constant thickness over
processes, a representative mask usable for one
exposure process may be used to prepare a tilt angle
table. Alternatively, a tilt amount of the mask 1
and/or the plate 5 may be calculated based on a

25   calculation result of the deformation amount of the
mask 1, and used to control the tilt angle.

FIG. 10 is a flowchart to acquire a tilt correction amount by gathering the above necessary data for adjustment and correction. A pattern mask for focus measurement is initially prepared to obtain the correction amount, and mounted onto an exposure apparatus. A next exemplary step arranges, at least at three places in a two-dimensional slit pattern image area, a light quantity measurement apparatus that sets its measurement focus position at a virtual plate surface position, and performs scan exposure using a focus-measurement pattern mask. A fluctuation amount of an image-surface position due to the deforming mask may be analyzed using a relationship between an irradiation position on the pattern mask and the measured light quantity and linear interpolation process of data. The analytical result would provide a calculated adjustment amount for a tilt mechanism, and a correction table.

An alternative embodiment prepares a focus-measurement mask pattern, loads it into an exposure apparatus, and then scan-exposes a focus-evaluation plate onto which photoresist has been applied. A focus state of the two-dimensional exposure areas may be measured through evaluation of the pattern that has been developed.

The method for identifying the focus position by actual exposure may use a plate with a photosensitive

material that requires no development, such as a

photochromic material, for quick and inexpensive

evaluations, instead of a plate with a development-

requiring photosensitive material such as photoresist.

5   The entire area on the plate may be measured for this

purpose, but a specific area on the plate may be

measured discretely for saving the measurement and

processing time.

Focus data is linearly interpolated for specific

10   representative points in the exposure area and

determines a stage tilt angle according to stage

positions. In adjusting a mechanism, the adjustment

amount for the tilt means is calculated based on the

data.

15   The mechanism is thus adjusted. In controlling a

stage tilt according to stage positions, a correction

table, for example, may be prepared and used for

control over the stage position.

Usual exposure step follows.

20   A description will now be given of an embodiment

of a liquid crystal panel fabrication method using the

above projection exposure apparatus.

FIG. 11 is a flowchart for manufacturing a liquid

crystal panel. In this embodiment, Step 1 (array

25   design step) designs a liquid crystal array circuit.

Step 2 (mask manufacture step) forms a mask having the

designed array pattern. Step 3 (plate manufacture

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step) manufactures a glass plate. Step 4 (array

manufacture step), which is also referred to as a

"pretreatment", forms actual circuitry on the glass

plate through the photolithography using the mask and

5   plate that have been prepared.

Step 5 (panel manufacture step), which is also

referred to as a "posttreatment", seals a back

peripheral that has been pasted together with a color

filter that has been manufactured by a separate step,

10   and implants liquid crystal. Step 6 (inspection step)

performs various tests, such as a performance test and

a durability test, for a liquid crystal panel module

that has assembled tabs and backlight and aged after

Step 5. A liquid crystal panel is finished and shipped

15   through these steps (Step 7).

FIG. 12 is a detailed flowchart for the array

manufacture in Step 4. Step 11 (cleaning before thin-

film formation) cleanses the glass plate as a

pretreatment prior to forming a thin film on its

20   surface. Step 12 (PCVD) forms a thin film on the

surface of the glass plate. Step 13 (resist

application step) applies desired resist to the surface

of the glass plate, and bakes it. Step 14 (exposure

step) exposes the array pattern on the mask onto the

25   glass plate using the above exposure apparatus.

Step 15 (development step) develops the exposed

glass plate. Step 16 (etching step) etches out parts

other than developed resist images. Step 17 (resist

stripping step) removes disused resist after etching.

These steps repeat until multi-layer circuit patterns

are formed onto the plate.

5   Use of the manufacture method of this embodiment

would easily manufacture a high-quality liquid crystal

panel.

The above-described embodiments facilitate

understanding the present invention, but do not intend

10   to limit its scope. Each element disclosed in the

above embodiments intends to cover all the

modifications and equivalents within the scope of the

present invention.

For example, while the above embodiments discuss a

15   life-size scanning exposure apparatus of a mirror

projection manner, the present invention is applicable

to an exposure apparatus that illuminates a mask using

arc-shaped illumination light, such as a step-and-scan

reduction projection exposure apparatus that has a

20   catadioptric system as a projection optical system.

FIG. 4 is a schematic view of principal part of a

fourth embodiment of this invention. This embodiment

differs from the first to third embodiments in that its

projection optical system is a catadioptric system.

25   The other structure is the same as described above.

This embodiment may incline the mask 1, the plate

5, or both the mask 1 and the plate 5.

The magnification correction in the scan direction

and the magnification correction in a direction

orthogonal to the scan direction are the same as

described for the first embodiment.

5   The instant embodiment forms an image inversed by

180° to the mirror projection type, uses the inverted

scan directions for the mask 1 and plate 5 as shown in

FIG. 4 compared to FIG. 2, and thus the inverted tilt

directions. Other structure is the same as the above.

10   The illumination light for exposure may use any

one of emission lines emitted from a mercury lamp (e.g.,

g-line, and i-line), KrF excimer laser (with a

wavelength of 248 nm), ArF excimer laser (with a

wavelength of 193 nm), F_2 laser (with a wavelength of

15   157 nm), Ar_2 laser (with a wavelength of 126 nm), YAG

laser, and other higher harmonic waves.

The present invention is applicable not only to an

exposure apparatus for fabricating a LCD device, but to

one for fabricating a semiconductor device, a thin film

20   magnetic head, and an image pick-up device (CCDs and

the like) as well as one that transfers a circuit

pattern to a glass plate, silicon wafer or the like in

order to make a reticle or mask.

Thus, the present invention may provide a scanning

25   exposure apparatus, as well as a device fabrication

method using the same, which facilitates projection

exposure onto a large screen with high resolution in

illuminating a mask that deforms due to its own weight, using arc-shaped illumination light to expose a pattern on the mask onto a plate through the projection optical system using a scanning exposure method, and a mask

5   support method for arranging in place an arc-shaped illuminated mask pattern image surface and a plate surface imaged by the projection optical system. when arc-shaped illumination light is used to illuminate a mask, and a pattern on the mask is

10   projected and exposed onto a plate by a projection optical system using a scanning exposure method, this invention can provide a scanning exposure apparatus, as well as a device fabrication method using the same, that can easily project and expose onto a large screen

15   with high resolution, however the mask may be deformed, by deforming the mask into an appropriate shape, and correcting the distance between the mask's arc-shaped illuminated area and the plate.

　　　　In addition, the present invention enables a

20   scanning exposure apparatus with arc-shaped illumination light to adjust the focus across the entire arc-shaped illumination area by tilting only the plate or both the mask and the plate concurrently.

　　　　The present invention may effectively correct

25   defocus due to the mask's gravity deformation.